

AD-A016 035

A STUDY TO DETERMINE A RELATIONSHIP BETWEEN FLYING
HOURS AND FLYING PROFICIENCY FOR THE KC-135A/Q
AIRCRAFT

William M. Henggeler, et al

Air Force Institute of Technology
Wright-Patterson Air Force Base, Ohio

August 1975

DISTRIBUTED BY:

NTIS

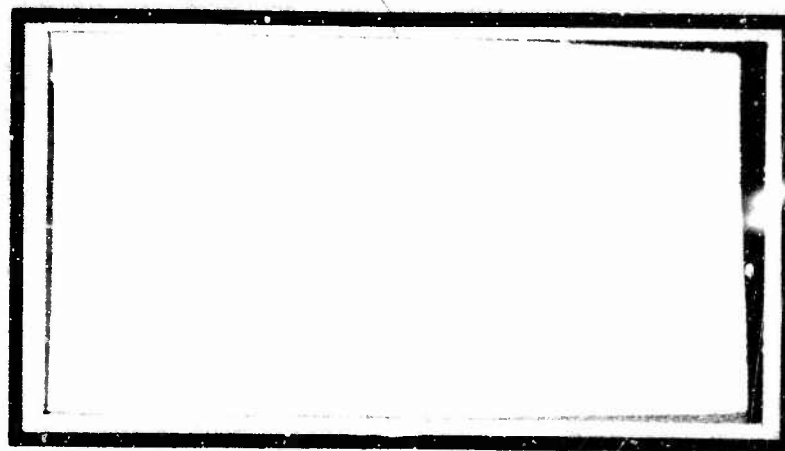
National Technical Information Service
U. S. DEPARTMENT OF COMMERCE

ADA016035

301139



DDC
RECEIVED
OCT 23 1975
C



UNITED STATES AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY
Wright-Patterson Air Force Base, Ohio

Reproduced by
**NATIONAL TECHNICAL
INFORMATION SERVICE**
US Department of Commerce
Springfield, VA. 22151

DISTRIBUTION STATEMENT A

Approved for public release;
Distribution Unlimited

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER SLSR 23-75B	2. GOVT ACCESSION NO.	3. REPORT'S CATALOG NUMBER
4. TITLE (and Subtitle) A STUDY TO DETERMINE A RELATIONSHIP BETWEEN FLYING HOURS AND FLYING PROFICIENCY FOR THE KC-135A/Q AIRCRAFT		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis
7. AUTHOR(s) William M. Henggeler, Captain, USAF Nestor K. Ovalle, 2D, Captain, USAF		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS Graduate Education Division School of Systems and Logistics Air Force Institute of Technology, WPAFB, OH		8. CONTRACT OR GRANT NUMBER(s)
11. CONTROLLING OFFICE NAME AND ADDRESS Department of Research and Communicative Studies (SLGR) AFIT/SLGR, WPAFB, OH 45433		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		12. REPORT DATE August 1975
		13. NUMBER OF PAGES 93
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES Approved for public release IAW AFR 190-17 <i>Jerry C. Hix</i> JERRY C. HIX, Captain, USAF Director of Information, AFIT		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Aircraft flying hours Percentage change in flying hours Average flying hours per UE Flying Evaluations Percentage change in evaluation results		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Thesis Chairman: Patrick J. Sweeney, Lieutenant Colonel, USAF		

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

The United States Air Force's operational readiness posture is a function of flying proficiency. Flying time is an important factor in achieving and maintaining an optimal level of flying proficiency. This study attempted to measure the effect of flying hour reductions (resulting from energy conservation and fuel reduction programs) on flying proficiency in order to determine if a statistical correlation can be applied for use as a predictor of flying proficiency as a function of flying time. This study was primarily concerned with the KC-135A/Q aircraft which are in operational use in the Strategic Air Command's 8th and 15th numbered Air Forces. The study encompassed the time period from January, 1973 through June, 1974 in order to provide a comparison of proficiency analysis before flying hours were significantly reduced and after their reduction. The study did not determine any statistically significant effect on flying proficiency. The methodology and analysis of this study could be used to generate future studies on all types of aircraft, and, therefore, extend the analysis to the effects of flying time on proficiency throughout the Air Force.

UNCLASSIFIED

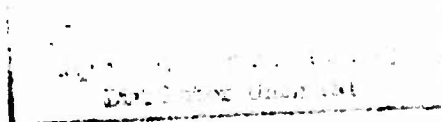
SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

DDC
RECEIVED
OCT 23 1975
C

A STUDY TO DETERMINE A RELATIONSHIP
BETWEEN FLYING HOURS AND FLYING
PROFICIENCY FOR THE KC-135A/Q
AIRCRAFT

William M. Henggeler, Captain, USAF
Nestor K. Ovalle, 2D, Captain, USAF

SLSR 23-75B



AFIT RESEARCH ASSESSMENT

The purpose of this questionnaire is to determine the potential for current and future applications of AFIT thesis research. Please return completed questionnaires to: AFIT/SLGR (Thesis Feedback), Wright-Patterson AFB, Ohio 45433.

1. Did this research contribute to a current Air Force project?

- a. Yes b. No

2. Do you believe this research topic is significant enough that it would have been researched (or contracted) by your organization or another agency if AFIT had not researched it?

- a. Yes b. No

3. The benefits of AFIT research can often be expressed by the equivalent value that your agency received by virtue of AFIT performing the research. Can you estimate what this research would have cost if it had been accomplished under contract or if it had been done in-house in terms of man-power and/or dollars?

a. Man-years _____ \$ _____ (Contract).

b. Man-years _____ \$ _____ (In-house).

4. Often it is not possible to attach equivalent dollar values to research, although the results of the research may, in fact, be important. Whether or not you were able to establish an equivalent value for this research (3 above), what is your estimate of its significance?

- a. Highly Significant b. Significant c. Slightly Significant d. Of No Significance

5. Comments:

Name and Grade

Position

Organization

Location

SLSR 23-75B

A STUDY TO DETERMINE A RELATIONSHIP
BETWEEN FLYING HOURS AND FLYING
PROFICIENCY FOR THE KC-135A/Q
AIRCRAFT

A Thesis

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the
Degree of Master of Science in Logistics Management

By

William M. Henggeler, BS
Captain, USAF

Nestor K. Ovalle, 2D, BS
Captain, USAF

August 1975

Approved for public release;
distribution unlimited

This thesis, written by

Captain William M. Henggeler

and

Captain Nestor K. Ovalle, 2D

has been accepted by the undersigned on behalf of the
faculty of the School of Systems and Logistics in partial
fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN LOGISTICS MANAGEMENT

DATE: 13 August 1975


COMMITTEE CHAIRMAN

ACKNOWLEDGEMENTS

All dedicated research depends on the assistance and cooperation of many people. The authors wish to express our appreciation to all those people within the Department of Defense who have contributed their time and effort in assisting us in developing the parameters of the thesis and in obtaining the data required for the research effort.

Particular gratitude is expressed to Major John Degrotte, Office of the Director of Training, Headquarters Strategic Air Command for his assistance in obtaining a large portion of the data required for this effort.

We also wish to convey our appreciation to Lt Colonel Patrick J. Sweeney, the thesis advisor and chairman, for his guidance and for his philosophy of flexibility which made our efforts a true educational experience.

Special thanks are extended to Captain Henggeler's wife, Pat, and Captain Ovalle's wife, Carol, for their patience, love, and devotion throughout these trying times.

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	iii
LIST OF TABLES	vi
 CHAPTER	
I INTRODUCTION	1
Statement of the Problem	1
Definition of Terms	2
Background	4
Relevance	7
Scope	8
Objective	9
Research Hypothesis	9
II RESEARCH METHODOLOGY	10
Universe Description	10
Population	11
Testing the Sample Groups (8th and 15th Air Forces)	12
Information Requirements	15
Data Base	20
Sampling Technique	20
Sampling Plan	21
Data Collection	23
Data Analysis	25
Analysis of the Accepted Sample	27
Testing the Research Hypothesis	28
Assumptions	30
Limitations	31
III DATA SCREENING AND ANALYSIS	32
Data Screening	32
Hypothesis Testing and Significance Level	33
Paired Comparison Test - Flying Hours	34

CHAPTER	Page
III	
Paired Comparison Test - Proficiency . .	36
The Chi-Square Test - Proficiency . . .	38
The Purpose of Regression Analysis . . .	44
Simple Linear Regression Model-Type I .	45
Transformation	46
Simple Linear Regression Model-Type II .	47
IV CONCLUSIONS AND RECOMMENDATIONS	53
Conclusions	53
Recommendations	58
APPENDICES	61
APPENDIX A - LISTING OF UNITS SELECTED FOR STUDY	62
APPENDIX B - LISTING OF REGRESSION PROGRAM	64
APPENDIX C - LISTING OF CURFIT PROGRAM . . .	72
SELECTED BIBLIOGRAPHY	82

LIST OF TABLES

Table		Page
1	PROGRAMMED AND ACTUAL KC-135 FLYING HOURS FOR FISCAL YEAR 1973 AND FISCAL YEAR 1974	12
2	MEAN (AVERAGE) FLYING HOUR COMPARISON . . .	13
3	FLYING HOUR AND EVALUATION RATING DATA FOR POPULATION A AND POPULATION B . . .	18
4	GROUPING OF SAMPLE DATA	24
5	KC-135 OPERATIONS MANPOWER STANDARDS . . .	48
6	GROUPING OF SAMPLE DATA FOR REGRESSION ANALYSIS USING UE FACTOR	50

CHAPTER I

INTRODUCTION

Statement of the Problem

Historically, it has been assumed that one of the major factors influencing the flying proficiency of pilots is the amount of time that they fly (10; 26). Currently, the major commands determine the number of flying hours required for each pilot (18:3-1). Through the use of flying, written, and simulator evaluations as well as Operational Readiness Inspection, competition meet, and training exercise results, the commands measure whether or not the desired level of proficiency is being maintained (26). There are various factors which affect the amount of flying hours available to the units. Some examples of these factors are the number of operationally ready aircraft, the logistical support for these aircraft (manpower and materiel) and the number of dollars (budget) available to procure and maintain the aircraft systems and logistical support (24: 1-1). Whenever any of these factors have limited the allocation of flying hours to the units, they have been considered constraints to flying proficiency. A major logistical support factor which has become a constraint

to the number of available flying hours is the availability of aviation fuels (3).

Sixty-five percent (65%) of the Department of Defense's petroleum supply is allocated to the support of aircraft operations. More significantly, the United States Air Force (USAF) uses ninety percent (90%) of its petroleum for aircraft operations (2). When there has been a significant decrease in the availability of fuel, flying hours have been decreased (3). Recently, the USAF flying hours were decreased as a result of the oil embargo in the fall of 1973 (1). Research is needed to determine the relationship between a decrease in flying hours and pilot proficiency.

Definition of Terms

Aircraft Incident - a mishap involving an aircraft that results in damage less than minor (20).

Combat Evaluation Group (CEVG) Evaluation - an evaluation of pilots in Strategic Air Command (SAC) units conducted on a notice or no-notice basis by highly qualified instructor pilots of the First Combat Evaluation Group (22:2-1).

Conditionally Qualified or Qualified with Additional Training - a member, unit, or an organization that demonstrated marginal performance or knowledge of procedures, techniques, or directives. However, such activity did not adversely affect the successful completion of the mission (22:6-1).

Major Aircraft Accident - the aircraft is destroyed or receives substantial damage in which the total direct manhours to replace the damaged component(s) equals or exceeds the manhours set for the aircraft by AFR 127-4, Investigating and Reporting US Air Force Accidents and Incidents, Attachment 6 (20).

Minor Aircraft Accident - the aircraft has less than substantial damage, but in which the total direct manhours to replace the damaged component(s) equals or exceeds the manhours set for the aircraft by AFR 127-4, Attachment 6 (20).

Operational Readiness Inspection - an inspection designed to periodically measure combat units performance and capability to accomplish its mission under simulated combat conditions (21).

Proficiency - a level of training and/or attainment that requires the student to demonstrate satisfactorily a capability and/or skill to accomplish a training item without further instruction (19:1-2).

Qualified - a member, unit, or an organization that demonstrated satisfactory performance or knowledge of procedures, techniques, or directives that would insure the successful completion of the mission (22:6-1).

Stratified Sample - a sampling technique where the universe is divided into groups to create homogeneous categories with respect to a particular characteristic(s)

under investigation (7:338).

Unit Standardization/Evaluation - a check administered by the local standardization section for the purpose of observing techniques of mission planning, briefing, and execution of a unit mission profile (22:2-6).

Unqualified - a member, unit, or an organization that demonstrated unacceptable performance or knowledge of procedures, techniques, or directives that would adversely affect the successful completion of the mission (22:6-1).

Background

The basic doctrine of the United States Air Force is founded on the principles that are necessary to the support of national objectives during peacetime and during periods of conflict (24:1-1). Military power is an instrument used to support the national objectives.

For military power to be pertinent as an instrument for national policy, the national leadership must be confident that it is effective, appropriate, and manageable [24:1-1].

The measure of effectiveness of the aerospace force used most often is that of destructiveness (24:1-1). The ability to evaluate destructiveness during peacetime is limited. Other methods of measuring the effectiveness of the force have been realized and are substituted for destructiveness to determine the state of readiness of the Air Force to support national objectives. One of the major areas in effectiveness measurement is the proficiency

of the individuals in the force (18:4-1; 22:1-1). A primary concern of this paper is the proficiency of pilots.

The aircrew evaluation program is one of several methods of determining pilot effectiveness. The program is established to provide scores on written, oral and flight evaluations which are designed to measure individual flying abilities (18:4-11). These scores are used as samples of the force capability to achieve combat objectives, i.e., destructiveness. A pilot may be qualified, conditionally qualified, or unqualified (18:Ch.4).

Another method for determining the effectiveness of the Air Force is the ratio of flying hours to the number of major flying aircraft accidents, to the number of minor flying aircraft accidents, and to the number of aircraft incidents. Those accidents and incidents that are pilot attributable, in part or in whole, are used in determining pilot effectiveness (5; 26).

Operational Readiness Inspections (ORI) are a third measurement of the capabilities of a unit and its personnel to achieve mission effectiveness. Because of the broad scope of the ORI evaluation, ORI deficiencies may be limited to those that are attributable to pilot effectiveness (5; 26).

By collecting, weighting, and evaluating the results of these criteria and other criteria (ie experience of the aircrew force and violations of Federal Aviation Regulations 26), the overall pilot effectiveness may be determined.

In addition, a minimum pilot proficiency standard can be established from these results.

To maintain these minimum standards which allow the immediate and successful completion of the mission, continuous training programs are established by the major commands (18:2-3). The programs outline various training policies and instructions used in maintaining the minimum standards. Also minimum requirements and the instructions for their completion are established.

The minimum number of flying hours for each pilot is one of the requirements established by AFM 60-1, Flight Management Policies, and by the flight training manuals of the major commands. The failure of an individual to complete a requirement requires a review of his effectiveness status (18:Ch.3).

The United States Air Force (USAF) flying hour program was affected during the fall of 1973 due to the oil embargo (3). The "energy crisis", as this period was called, first led to what some energy experts thought to be only a short-term cutback in USAF flying during the crisis period (3). It became apparent that the "crisis" could not be solved immediately and could last indefinitely, creating a serious problem. For the first time in this Nation's history, a great deal of uncertainty existed concerning the Nation's future fuel resources, their location and quantity (14). In the face of this uncertainty, various voluntary and regulatory programs have been and are being evaluated.

One Federal program which has been instituted is the Energy Conservation Program (3). This program has strongly affected the Department of Defense and the Air Force.

The Department of Defense's Energy Conservation Program has established an overall conservation goal of fifteen percent (15%) reduction of energy consumption for Fiscal Year 1974 and is programmed to continue through Fiscal Year 1975 (3). The reduction rate is taken by using Fiscal Year 1973 as the base period to which the fifteen percent (15%) reduction will be applied.

As a result of these programmed reductions, the USAF flying hours have also been reduced (3). The actual flying hour reductions are not uniformly applied to the Air Force commands; each command has effected a flying hour reduction within a range of five to fifteen percent (5-15%) (3).

Relevance

This research attempted to determine if there has been a change in flying proficiency due to reductions in flying hours.

The evaluation of a change in flying proficiency is relevant and essential in determining adequate support of the national objectives. If resulting changes in flying proficiency become detrimental to the support of the national objectives, then one or more of the following actions could be considered.

1. To reallocate fuel among all users within the Nation to maintain the required proficiency.
2. To reevaluate the proficiency standards.
3. To increase utilization of the available flying time for proficiency.
4. To emphasize non-flying training techniques, i.e., simulators in support of maintaining proficiency.

Scope

In order to determine if there is a relationship between the proficiency of a pilot and the number of flying hours, pilots assigned to the Strategic Air Command's (SAC's) 8th and 15th Numbered Air Forces were selected as subjects for the research. When this study was initiated SAC's two numbered Air Forces were designated 2nd Air Force and 15th Air Force. During this study 2nd Air Force was redesignated 8th Air Force. Thus in this study, the current designations of SAC's two numbered Air Forces will be 8th and 15th Air Forces. The type of aircraft flown by the subject pilots is the KC-135 "Stratotanker." In choosing the Strategic Air Command and the KC-135 consideration was given to the availability of statistical data from the numbered Air Forces (4; 9; 10; 11; 12). In order to effect an accurate study of the relationship between proficiency and flying hours, SAC's KC-135s were selected because they experienced a significant cutback (26%) during the period Fiscal Year 1973 and 1974 (3).

Objective

The objective of this study was to evaluate the relationship, if any, of reduced flying hours for KC-135 aircraft on the proficiency of KC-135 pilots. This evaluation provided a measurement of the dependence of KC-135 pilot proficiency on the actual flying hours used by the pilots.

Research Hypothesis

The proficiency of KC-135 pilots will exhibit a difference when flying hours are decreased as evidenced by differences in flying evaluation ratings.

CHAPTER II

RESEARCH METHODOLOGY

Universe Description

General. Air Force pilots may be classified according to the major command to which they are assigned. In the Strategic Air Command (SAC), three major types of categories are used (22; 17:45).

The first category contains pilots flying bomber type aircraft. B-52 pilots flying heavy bombers and those pilots flying medium bombers (FB-111) are in this category.

In the second category are pilots flying reconnaissance type aircraft. This category includes propeller driven aircraft as well as jet aircraft. Also listed in the reconnaissance category are pilots flying RC-135, EC-135, and KC-135R type aircraft.

In the last category are the air refueling pilots. This category consists of two types of pilots; those pilots flying the KC-135A and those flying the KC-135Q.

In SAC, the concepts and policies used for training and maintaining pilots at an assigned proficiency level are broken out according to these three categories. Thus the proficiency requirements for a KC-135A/Q pilot are not the same as those for a KC-135R pilot and therefore the KC-135R

pilots will not be included in the study.

Universe of Pilots to be Studied. In this research the pilot universe to which inference was made for hypothesis testing was limited to the KC-135A/Q pilots assigned to Strategic Air Command during the period from January, 1973 through June, 1974. The KC-135 aircraft include 615 aircraft divided up into thirty-eight squadrons (18:45). A small group of KC-135 pilots has been excluded from this study. This excluded group included the special mission tankers, and reconnaissance models, and the KC-135R. In addition to affording a large sample for research, the KC-135A/Q pilots are all evaluated at unit and command level by the same testing standards (22). This research infers to the universe of KC-135A/Q pilots assigned to SAC during the period from January, 1973 through June, 1974.

Population

In order to test the research hypothesis and to accomplish the objective of this thesis, the universe of KC-135A/Q pilots was divided into two populations. The KC-135A/Q pilots who flew during the period January through June, 1973 were one population and the KC-135A/Q pilots who flew during the period January through June, 1974 were the second population. The total number of actual and programmed flying hours for the KC-135A/Q was different in each population. Table 1 is the distribution of KC-135

flying hours by fiscal year (3).

TABLE 1

PROGRAMMED AND ACTUAL KC-135 FLYING HOURS
FOR FISCAL YEAR 1973 AND FISCAL YEAR 1974

FISCAL YEAR	PROGRAM	ACTUAL	PCT CHANGE BETWEEN PROGRAM	PCT CHANGE BETWEEN ACTUAL
73	330,326	331,884		
74	245,693	229,629	-26%	-31%

Source: Energy Management Division, Headquarters USAF.

Each population contained pilots from the 8th Air Force and from the 15th Air Force. The KC-135A/Q pilots from the 8th and 15th numbered Air Forces were combined to form one large sample group which was used to test the hypothesis. However, prior to combining the KC-135A/Q pilots from the 8th and 15th Air Forces, a test was performed on each numbered Air Force to check for possible bias differences. The following section describes the purpose and methodology of this test.

Testing the Sample Groups (8th and 15th Air Forces)

In order to assure a sufficiently large sample from which to test the research hypothesis, data from two SAC numbered Air Forces were used. Prior to combining the data

from the 8th and 15th numbered Air Forces, a bias difference check was performed on each numbered Air Force.

Bias difference is defined as a sample whose mean is not normally distributed with the population mean. The bias tested, was the difference between the mean flying hours per unit in the population, SAC's KC-135A/Q units, and the mean flying hours per unit in each sample group, 8th and 15th Air Forces' KC-135A/Q units, during the period from January, 1973 through June, 1974. Furthermore, the comparisons of mean flying hours per unit were made for each of the two population periods, January through June, 1973 and January through June, 1974. The comparisons used the information symbolically identified in Table 2.

TABLE 2

MEAN (AVERAGE) FLYING HOUR COMPARISON

<hr/>			
Population B (before) - Jan - Jun 1973			
	<u>SAC KC-135A/Q</u>	<u>8th AF KC-135A/Q</u>	<u>15th AF KC-135A/Q</u>
	Units	Units	Units
Flying Hours Per Unit	\overline{SAC}_B	\bar{X}_B	\bar{W}_B
Population A (after) - Jan - Jun 1974			
Flying Hours Per Unit	\overline{SAC}_A	\bar{X}_A	\bar{W}_A
<hr/>			

The test which was performed on the mean differences was a paired comparison of the unit flying hours for the

January - June, 1973 period and the January - June, 1974 period. The actual differences were evaluated against a critical difference at a ten percent (10%) level of significance. The differences tested are described by the following questions:

1. Is the difference, if any, between the average number of flying hours per KC-135A/Q unit in 8th Air Force for the period January - June, 1973 and the average number of flying hours per KC-135A/Q unit in 8th Air Force for the period January - June, 1974 statistically significant?

This question is symbolically represented as follows:

$$a. H_0: \bar{X}_B = \bar{X}_A \text{ (No Difference)}$$

$$b. H_1: \bar{X}_B \neq \bar{X}_A \text{ (Difference)}$$

2. Is the difference, if any, between the average number of flying hours per KC-135A/Q unit in 15th Air Force for the period January - June, 1973 and the average number of flying hours per KC-135A/Q unit in 15th Air Force for the period January - June, 1974 statistically significant?

This question is symbolically represented as follows:

$$a. H_0: \bar{W}_B = \bar{W}_A \text{ (No Difference)}$$

$$b. H_1: \bar{W}_B \neq \bar{W}_A \text{ (Difference)}$$

If both 8th and 15th Air Forces are statistically significant, then the two groups, 8th and 15th Air Forces' units, would be combined to test the research hypothesis.

Symbolically, this would be represented by $\overline{SAC}_B \neq \overline{SAC}_A$; that is, there is a statistically significant difference in flying hours for KC-135 A/Q units in SAC between the January - June, 1973 period and the January - June, 1974 period. This check, therefore, was required in order to establish the premise on which the research hypothesis being tested was based; that is, that a flying hour decrease will affect flying proficiency.

The succeeding sections of this chapter which address the information requirements, and, the plan and analysis of the sample, show a breakout of the data by 8th and 15th Air Force. This breakout is not in conflict with the proposal to combine the two numbered Air Force groups. The distinction between the two groups was maintained until the bias check had been accomplished. The data collection, analysis and testing of the hypothesis sections do not reflect a separation of 8th and 15th Air Forces.

Information Requirements

The following research hypothesis was tested:

The proficiency of KC-135 pilots will exhibit a difference when flying hours are decreased as evidenced by differences in flying evaluation ratings.

To evaluate this hypothesis, an analysis was made of the flight evaluations exhibited in one population against the flight evaluations in the other population. The two

populations were previously defined as follows:

1. Population B (B for before) included January through June, 1973.
2. Population A (A for after) included January through June, 1974.

Pilot evaluation ratings are defined as one of two possible outcomes, qualified or unqualified. The variables qualified and unqualified have been previously defined as follows:

1. Qualified - a member, unit or organization that demonstrated satisfactory performance or knowledge of procedures, techniques, or directives that would insure the successful completion of the mission (22:6-1).
2. Unqualified - a member, unit, or an organization that demonstrated unacceptable performance or knowledge of procedures, techniques, or directives that would adversely affect the successful completion of the mission (22:6-1).

The evaluation ratings for each population consist of both unit standardization/evaluations (evaluations by unit standardization/evaluation personnel of pilots within the unit) and SAC standardization/evaluations by the Combat Evaluation Group (CEVG) (17). The overall mission of the CEVG is to " ... provide for standardization/evaluation and bomb scoring programs and such contingency warfare support as may be assigned [17:10-8]." The standardization mission is performed by CEVG monitoring results of unit standardiza-

tion and evaluation activities. This allows CEVG to note possible trends in weak and unsatisfactory areas.

Additionally, CEVG provides for standardization/evaluation within SAC by annual visits to all SAC units for the purpose of inspecting various components of the unit's standardization/evaluation program (15:43). In this research, the evaluation ratings from CEVG and the unit evaluations were combined for each unit. The combination of the evaluation ratings was justified because there is no difference in the evaluations except that in one case the local standardization personnel perform the evaluation and, in the other case, SAC personnel perform the evaluation. Both levels of evaluation are accomplished using the same criteria (17). The evaluation ratings' results identified the percentage of pilots in each squadron who achieved a qualified score, thereby affording data at the ratio level.

The flying hour data was obtained from the two numbered Air Forces, 8th and 15th for each of the two population periods. The flying hour data was further broken out by units (as was previously noted, this is also the case with the evaluation rating data). This research made the assumption that the average flying hour per pilot in a unit could be calculated by averaging the unit data according to the number of pilots assigned. Therefore, the flying hour data identified the average flying hours flown by pilots within each unit.

The information collected is shown in Table 3.

TABLE 3

FLYING HOUR AND EVALUATION RATING DATA
FOR POPULATION A AND POPULATION B*

<u>Population B (before) - Jan - Jun, 1973</u>		
	<u>8th AF</u>	<u>15th AF</u>
Flying Hours	X_{Bi}	W_{Bi}
Eval. Ratings	Y_{Bi}	Z_{Bi}

<u>Population A (after) - Jan - Jun, 1974</u>		
Flying Hours	X_{Ai}	W_{Ai}
Eval. Ratings	Y_{Ai}	Z_{Ai}

* The table includes both 8th AF and 15th AF. The data from each of these sample groups was combined as a result of the bias check previously identified.

The variables shown in Table 3 are defined as follows:

1. For Population B (January through June, 1973). The explanation that follows will treat one of the two numbered Air Forces for purpose of simplicity. It should be noted that the same explanation to be given applies to both numbered Air Forces, the only difference being the symbols used for each Air Force.

a. X_{Bi} is the independent variable for 8th Air Force in this population. This variable represents the flying hours during the January through June, 1973 period of the individual units in 8th Air Force.

b. Y_{Bi} is the dependent variable for 8th Air Force in this population. This variable represents the evaluation ratings of individual pilots in 8th Air Force. Specifically, the variable identifies the percentage of pilots who achieved an unqualified evaluation rating.

2. Population A (January through June, 1974). The explanation that follows will treat one of the two numbered Air Forces for the purpose of simplicity. It should be noted that the same explanation to be given applies to both numbered Air Forces, the only difference being the symbols used for each Air Force.

a. X_{Ai} is the independent variable for 8th Air Force in this population. This variable represents the flying hours during the January through June, 1974 period of individual units in 8th Air Force.

b. Y_{Ai} is the dependent variable for 8th Air Force in this population. This variable represents the evaluation ratings of individual pilots in 8th Air Force. Specifically, the variable identifies the percentage of pilots who achieved an unqualified evaluation rating.

Data Base

SAC KC-135 flying units follow the training requirements set forth in Strategic Air Command Manual (SACM) 51-8, Training Concepts, Policies, and Instructions - SAC Units and Aircrews. Additionally, these units are evaluated in accordance with standards and procedures of SACM 60-4, Standardization Evaluation Program. The evaluation data, which were collected and operated on to obtain the information described above, is generated according to the guidelines set forth in SACM 60-4. The data from the evaluations were collected directly from the Combat Evaluation Group Headquarters. This headquarters collects and maintains both the CEVG and unit evaluation results for KC-135 pilots (10).

The flying hour data were obtained from the two numbered Air Forces. The flying hour data were collected by the two population periods - Population B (January through June, 1973) and Population A (January through June, 1974) - and were listed by units. An average number of flying hours per pilot can be identified by taking the unit flying hours and dividing by the number of pilots per unit. The sampling technique and plan are presented in the following section of this proposal.

Sampling Technique

A preliminary pilot study was made based on flight evaluations obtained from randomly selected air refueling

units. Each of the units had varying reductions in the amount of flying time for the period January through June, 1974. Half of the units were from 8th Air Force and the other half were from 15th Air Force.

The purpose of the pilot study was to determine if an adequate number of flight evaluation observations were available from the units. Using as a guide 30 observations or more from the population (28), all the units in the pilot study had at least 70 flight evaluations. Thus, based on this pilot study, all units did provide a sufficient number of flight evaluations in order to perform the required analysis and test the research hypothesis.

While all units were acceptable based on the minimum number of flight evaluation observations, some of the units were not acceptable based on flying hours. The unacceptable units were not operating at their base of assignment but the units were split-up and dispersed on temporary duty overseas. These units did not have sufficient number of hours flown as intact units. Therefore, these units were excluded from the study.

Sampling Plan

The sampling process used in the research was based on stratified samples. A stratified sample divides the universe into homogeneous categories with respect to a particular characteristic(s) which are under investigation.

Thus, within a selected category, observations should be more similar to one another than those observations selected from different categories. Helmstadter (7:388) notes that an increase in precision is gained by using stratified sampling through the use of homogeneous categories as opposed to a simple random sample. It should be noted that in a stratified sample, the number of observations selected from each of the categories is not always proportional to the population.

1. A listing of all the unit's flying evaluations of pilots and CEVG evaluations of pilots for the time periods of January through June, 1973 and January through June, 1974 were obtained from the Combat Evaluation Group's Analysis and Special Projects Division. This provided a complete listing of all flight evaluations for the populations under consideration.

2. A listing of the flying hours flown for both time periods was collected at 8th and 15th Air Forces' Director of Training Divisions. The differences in the two listings of flying hours show the percentage decrease/increase in flying hours for each unit (for purposes of testing the hypothesis, this research made the assumption that a specified percentage decrease/increase in a unit, will be on the average, the same decrease/increase for pilots in the unit).

With the change in unit flying hours shown, these decreases/increases were divided into approximately 25

categories. All the units were categorized according to the respective percentage decrease/increase of flying hours (using approximately 25 categories) identified from the population period "before" and the population period "after."

Data Collection

The evaluation ratings and flying hours, identified by numbered Air Forces and by units (squadrons), were obtained from CEVG, 8th Air Force and 15th Air Force. The sampling technique and plan used have been previously described. This section of the plan describes the structuring of the data for the purpose of analysis and testing. The succeeding section will describe the design for testing the research hypothesis.

The sampling data collected were identified by the dependent and independent variables for each population. After the sample was selected, the variables were grouped as shown in Table 4. The grouped data in Table 4 are defined as follows:

1. Column 1. The sample Y_{Bi} data are the dependent variables. This data represented the sample pilots' evaluation ratings' results (percentage unqualified) for the period January through June, 1974.

2. Column 2. The sample Y_{Ai} data are the dependent variables. This data represented the sample pilots' evaluation ratings' results (percentage unqualified) for the period January through June, 1974.

TABLE 4
GROUPING OF SAMPLE DATA*

<u>Dependent Variable</u>			<u>Independent Variable</u>				
Y_{Bi} (1)	Y_{Ai} (2)	$(Y_{Bi}-Y_{Ai})^{**}$ (3)	$(Y_{Di})^2$ (4)	X_{Bi} (5)	X_{Ai} (6)	$(X_{Bi}-X_{Ai})^{**}$ (7)	$(X_{Di})^2$ (8)
Y_{B1}	Y_{A1}	Y_{D1}	$(Y_{D1})^2$	X_{B1}	X_{A1}	X_{D1}	$(X_D)^2$
Y_{B2}	Y_{A2}	Y_{D2}	$(Y_{D2})^2$	X_{B2}	X_{A2}	X_{D2}	$(X_{D2})^2$
.
.
.
Y_{Bi}	Y_{Ai}	Y_{Di}	$(Y_{Di})^2$	X_{Bi}	X_{Ai}	X_{Di}	$(X_{Di})^2$

* The data presented above represents samples taken from both 8th and 15th Air Forces. This combination was predicated on a satisfactory bias check as described previously in the section on testing the sample groups.

** Column 3 represents Y_{Di} , Column 7 represents X_{Di} .

3. Column 3. Variable Y_{Di} represented the difference between Y_{Bi} and Y_{Ai} , showing the pilots' evaluation ratings' differences between the January through June, 1973 period and the January through June, 1974 period.

4. Column 4. $(Y_{Di})^2$ is the square of Y_{Di} .

5. Column 5. The sample X_{Bi} data are the independent variables. This data represented the flying hours per unit for the period January through June, 1973.

6. Column 6. The sample X_{Ai} data are the independent variables. This data represented the flying hours per unit for the period January through June, 1974.

7. Column 7. X_{Di} represents the difference between X_{Bi} and X_{Ai} showing the difference between flying hours for each unit between the January through June, 1973 period and the January through June, 1974 period.

8. Column 8. $(X_{Di})^2$ is the square of X_{Di} .

Data Analysis

The data analysis portion of the research utilized the data collected as described above. The process consisted of three major stages:

1. Purging of the invited sample,
2. Operating on data produced from the sample, and
3. Analysis of the accepted sample.

A brief description of each stage follows:

Purging the Invited Sample. The procedure was to examine the data relative to the criterion described in the section on sampling techniques. It was pointed out in that section that the preliminary study revealed that some of the data collected could not be used.

As was noted there, the only reason found which did invalidate the data was units not operating at their base assignment; instead, the units were split-up and dispersed on temporary duty overseas. These units did not have sufficient number of hours flown as intact units. The results of this stage of data analysis produced an accepted sample for each period of time being evaluated.

Additionally, as was noted in the section on testing the sample groups, the combination of data from 8th and 15th Air Forces was predicated on a satisfactory bias check.

Operating on the Accepted Sample. This procedure consisted of several stages. First, for a combined 8th and 15th AF sample, as shown in Table 4, measures of the independent and dependent variables were gathered, the differences between the dependent variables for each of the two periods was calculated, and the differences between the independent variables for each of the two periods was also calculated (see columns 3 and 7, Table 4). The next step was to calculate the sum of the above referenced columns. Additionally, a quantity \bar{n} was calculated.

Quantity n equals the number of observations or i . These calculations were used to perform a paired comparison test and to perform a regression analysis.

Analysis of the Accepted Sample

The first operation performed was that of using a "paired comparison" test on the average flying hour difference and on the average flying proficiency difference for the two populations, the 1973 time period and the 1974 time period. It was assumed that the two samples used were independent.

This means that each sample is representative of a different population and the values obtained in one sample do not predetermine the values obtained in the other sample [27:106].

The research was not primarily concerned with obtaining the exact value of the mean flying hour or the exact value of the mean flying proficiency of either population. Rather the major area of interest was to reasonably suppose that the mean flying hour and the mean proficiency of the 1973 time period were not the same as the mean flying hour and the mean proficiency of the 1974 period.

Thus the question concerns the mean of the differences between the before period, 1973 and the after period, 1974 for both flying hours and flying proficiency. It was necessary to calculate the standard error of the estimate of the differences. The true values for the variances of the

populations were unknown to the researchers. Therefore the student's t distribution was used in place of the z statistic.

Also, from the operation on the data described above, a sample correlation coefficient was derived. An analysis of the statistical significance of the data, using the correlation coefficient, R , gave an immediate picture of how closely the two variables move together (27:Ch.14). The coefficient of determination, R^2 , was also computed. This coefficient, R^2 , showed the proportion of the total variation explained by fitting the independent variable, flying hours, in a regression model on the dependent variable, evaluation ratings (27:ch.14). They do serve as indices of the relationship between the two research variables. Additionally, the regression coefficient of the independent variable, B , and the standard error of the regression coefficients, S_B , were calculated. These calculations will be further described in the following section.

Testing the Research Hypothesis

The research hypothesis tested was:

The proficiency of KC-135 pilots will exhibit a difference when flying hours are decreased as evidenced by differences in flying evaluation ratings.

First it was necessary to verify a decrease in flying hours from January through June, 1973 to January through

June, 1974. This was validated by evaluating the mean difference flying hours, using the paired comparison test described in the previous section. Note that this mean difference for the independent variable was represented by the symbol \bar{X}_{Di} .

Next was the formulation of a linear regression model based on the Gauss-Markov theorem of Least Squares Estimators (25:Chap.12). In the regression it was necessary to calculate the fixed variable and the variable coefficient of the independent variable X_{Di} . The equation estimated was:

$$Y_D = A + BX_D.$$

A is the fixed variable and B is the coefficient of the independent variable. As was stated previously, the coefficient of determination, R^2 , was calculated. R^2 is the proportion of the total variation in Y explained by fitting the regression. It is a dimensionless index of the explained variation to the total variation (27:342). Also, as was previously noted in the section on analysis of the accepted sample, the standard error of the regression coefficient was calculated. This calculation will be used to perform an individual test on the regression coefficient (t test).

A necessary step in testing the regression model was the t test on the significance of the regression coefficient. This will be a two-tailed test using a ten

percent (10%) level of significance. The test hypothesis was of the form:

$$H_0 : B_i = 0 \quad B_i = \text{coefficient of the independent variable}$$

$$H_1 : B_i \neq 0$$

The test was an evaluation of a t sample value calculated by using the regression coefficient, B, and the standard error of the regression coefficient, S_B ; where t sample = $\frac{B}{S_B}$. The t sample was compared to a t critical value taken from the Standard Mathematical Tables. If t sample was greater than t critical, the null hypothesis would be rejected. If the null hypothesis is rejected, then the independent variable X_{Di} could be used as a measure of Y and the inference would be that there was a positive relationship between the independent variable, flying hours, and the dependent variable, proficiency (8; 27).

The final step was the calculation of a probability value using the calculated t sample. The probability value indicates the expected risk taken when the null hypothesis is rejected (27:189-192).

Assumptions

1. The time periods (January through June, 1973 and January through June, 1974) were of sufficient length to yield valid data pertaining to the objective of this study. This assumption was based on the requirement for

a statistically significant decrease in flying hours. The "energy crisis" in the fall of 1973 brought about a significant decrease in the flying hours allotted to KC-135A/Q.

2. The samples from the two populations were not biased by the exclusion of those observations described in the sampling technique section and were random variables.

3. The data collected were assumed to be valid. This assumption was based on the methodology used in the gathering and processing of the data.

4. The unit evaluations and CEVG evaluations for all of the squadrons were considered to be strictly objective. This assumption is based on SACM 60-4, Standardization/Evaluation Program.

Limitations

1. The relationships derived from the research will apply only to KC-135A/Q pilots during the periods January through June, 1973 and January through June, 1974.

2. The relationships derived from the research may be caused by other variables that were unknown at the time of the experiment.

CHAPTER III

DATA SCREENING AND ANALYSIS

Data Screening

In the section entitled "Sampling Technique" in the previous chapter, one reason for elimination of certain data was described. As was noted there, data were invalidated for certain entire units not operating at their base of assignment during some part of the time period included in this research; also, at least one unit was not actively assigned to 8th Air Force during the 1973 period of this research. Additionally, data for individual crew members, which includes their flying time while deployed to such locations as Torrejon Air Base, Spain and Eielson Air Base, Alaska, were not used because the flying time did not reflect 8th Air Force or 15th Air Force flying time.

Those units assigned to Castle Air Force Base, the 93rd Air Refueling and the 924th Air Refueling Squadrons, were not considered as part of this research. The reason for their exclusion was that Castle Air Force Base is the KC-135 combat crew training base and as such includes many student pilots. In order to avoid bias to the data, it was

decided to distinguish between student pilots and non-student pilots. However, for Castle Air Force Base it was not possible to distinguish the flying hours for the non-student pilots from those of the student pilots, therefore, the data from Castle Air Force Base were excluded in its entirety.

Additionally, while the KC-135A/Q aircraft are flown at Offutt Air Force Base, their function is to support pilot training for those pilots who are assigned to the 55th Strategic Wing. This wing's mission deals with the EC-135 and thus KC-135 A/Q are used solely for training purposes. Therefore, the data from this unit were not considered part of the research.

Hypothesis Testing and Significance Level

In evaluating a hypothesis, a major area of concern is accepting the operational statement of the research hypothesis (H_1) with some degree of confidence so that the null hypothesis (H_0) is not erroneously rejected. The probability of being wrong in rejecting the null hypothesis is called Type I error, and the probability of committing this error, p , is equal to the significance level (α) for which the hypothesis is tested (12:9). Thus to accept H_1 for a specified level of significance, it is necessary to reject H_0 and to prove that the probability of rejecting H_0 in error is less than the specified significance level.

For all of the hypothesis testing in this research a significance level of .10 was selected as stated previously. Thus the intent of the researchers was to reject the null hypothesis and accept the research hypothesis with a ten percent or less chance of being wrong in rejecting the null hypothesis. A researcher may be willing to accept a higher probability of committing a Type I error in an effort to reduce the probability of committing a Type II error (probability of being wrong in accepting the null hypothesis) if the researcher will increase the level of significance in evaluating the data (12:9).

Paired Comparison Test - Flying Hours

The initial step necessary to complete the research was to establish a significant statistical decrease in flying hours for the two populations - the 1973 time period and the 1974 time period. The manner in which this was done was by performing a paired comparison test on 8th Air Force's flying hours and a paired comparison test on 15th Air Force's flying hours. The following statistics were calculated

<u>8th Air Force Flying Hours Difference</u>		<u>15th Air Force Flying Hours Difference</u>	
\bar{D}_i	= 224.82	\bar{D}_i	= 190.88
S_D	= 487.31	S_D	= 319.23
n	= 11	n	= 8

*NOTE: X_{Di} of Table 4 is the same as D_i used in this section.

The hypothesis tested was whether or not a conclusion could be made that a significant decrease was observed between the 1973 period and the 1974 period. The hypothesis was tested at a .10 level of significance. The hypothesis is presented as:

$$H_0 : B \leq A$$

$$H_1 : B > A$$

Thus if H_0 is accepted as being true, then there would be no decrease between the 1973 and 1974 populations with respect to flying hours. If H_1 is accepted as being true, then there is a decrease between the 1973 population and the 1974 population with respect to flying hours.

To test the null hypothesis, the critical difference, \bar{D}_C , was calculated as follows:

$$\bar{D}_C = \bar{D} \pm t \frac{S_D}{\sqrt{n}}$$

Where S_D was the standard error of the estimate of the difference between the two means, and was calculated as follows:

$$S_D = \left[\frac{\sum D_i^2 - \bar{D} \sum D_i}{n-1} \right]^{1/2}$$

Where n was the number of pairs used in making the test.

The results of the paired comparison tests are as follows:

8th Air Force
Flying Hours Difference

$$\bar{D}_i = 224.82$$

$$\bar{D}_C = 201.59$$

$$t = 1.372$$

15th Air Force
Flying Hours Difference

$$\bar{D}_i = 190.88$$

$$\bar{D}_C = 170.73$$

$$t = 1.415$$

Because the difference, \bar{D}_i , which was calculated for both 8th and 15th Air Forces was more than the critical difference value, \bar{D}_C , there is a statistical basis for rejecting the null hypothesis. Therefore, this was interpreted as saying that evidence indicates that the flying hour averages of the two time periods are not the same and gives an indication that a real decrease did exist between the two time periods.

As was stated previously, 8th Air Force and 15th Air Force would be combined if both showed a statistical decrease. As a result of the paired comparison test, the two numbered Air Forces were grouped together and were treated as such for the remaining statistical tests and evaluations.

Paired Comparison Test - Proficiency

A paired comparison test was used to determine if a significant statistical difference in proficiency existed between the 1973 time period and the 1974 time period. Because of the structuring of this test, the difference in proficiency which might be indicated could be the result of an improvement or a decline in proficiency. If a difference was statistically significant then a further test can

determine if the difference was attributable to an increase or decrease in proficiency. The following statistics were calculated:

Proficiency Difference

$$* \bar{D}_i = .9356$$

$$S_D = 3.2125$$

$$n = 18$$

*NOTE: Y_{Di} of Table 4 is the same as D_i used in this section.

The hypothesis tested was whether or not a conclusion could be made that a significant difference was observed between the 1973 period and the 1974 period. The hypothesis was tested at a .10 level of significance. The hypothesis is presented as:

$$H_0 : \mu_B - \mu_A = 0$$

$$H_1 : \mu_B - \mu_A \neq 0$$

Thus if H_0 is accepted as being true, then the 1973 population and the 1974 population are not different with respect to proficiency. If H_1 is accepted as being true, then the 1973 population and the 1974 population are different with respect to proficiency.

The results of the paired comparison test are as follows:

Proficiency Test

$$\bar{D}_i = .9356$$

$$\bar{D}_C = 1.3175$$

$$t = 1.740$$

Because the difference, \bar{D}_i , which was calculated was less than the critical difference value, \bar{D}_C , there is no statistical basis for rejecting the null hypothesis. Therefore, this was interpreted as saying that the evidence indicates that the proficiency levels of the two time periods are the same and gives indication that no real difference in proficiency did exist between the two time periods.

The Chi-Square Test - Proficiency

A parametric statistical test is a test which specifies certain restrictions about the population parameters. For example, some of the student t test's restrictions are that the observations be independent, the observations be drawn from normally distributed populations, and the observations have the same variance. Since these restrictions are not usually tested, they are assumed to be true. Thus the meaningfulness of the parametric test depends upon the assumptions holding true.

A non-parametric statistical test is a test which does not specify certain restrictions about the population

parameters. There are certain assumptions associated with most non-parametric tests but these assumptions are fewer and much weaker than those of the parametric tests. The non-parametric tests do not require measurements as strong as that of the parametric test. The parametric test requires measurement on at least the interval scale while the non-parametric may apply to the nominal scale (13 :Ch.3).

The paired comparison test for proficiency was considered to be a parametric statistical test. Thus the restrictions of the paired comparison test were assumed to have been met by the researchers. In an effort to reduce the restrictions and assumptions, the researchers performed a non-parametric statistical test, a Chi-Square test.

The function of the Chi-Square test was to determine the significance of difference between the proficiency of the 1973 population and the 1974 population. For the purpose of explaining the Chi-Square test in determining if the 1973 population and 1974 population differ with respect to proficiency, proficiency is defined, the null and research hypothesis are stated, and the level of significance is established.

U = an evaluation in which the pilot demonstrated unacceptable performance or knowledge of procedures, techniques, or directives that would have adversely affected the successful completion of the mission.

- Q = an evaluation in which the pilot demonstrated satisfactory performance or knowledge of procedures, techniques, or directives that would insure the successful completion of the mission.
- B = an evaluation in which the pilot demonstrated his level of proficiency during the January to June, 1973 time period.
- A = an evaluation in which the pilot demonstrated his level of proficiency during the January to June, 1974 time period.
- H_0 = the proficiency as exemplified by the percent of unqualified (U) for the 1973 time period equals the proficiency as exemplified by the percent of unqualified (U) for the 1974 time period $p(U/B) = p(U/A)$.
- H_1 = the proficiency as exemplified by the percent of unqualified (U) for the 1973 time period does not equal the proficiency as exemplified by the percent of unqualified (U) for the 1974 time period $p(U/B) \neq p(U/A)$.
- α = .10.

Thus if H_0 is accepted as being true, then the 1973 population and the 1974 population are not different with respect to proficiency. If H_1 is accepted as being true, then the 1973 population and the 1974 population are

different with respect to proficiency. The following is a contingency table for the observed values.

O_{ij}

		B	A	
U	I	176	195	371
Q	III	3111	4009	7120
		3287	4204	<u><u>7491</u></u>

The numbers to the right and below the table are the observed number of evaluations from the sample that apply to each of the events as described above and to the left of the table. Thus there were 371 unqualified evaluations and 7120 qualified evaluations. There were 3287 evaluations in the 1973 time period and 4204 evaluations in the 1974 time period. The total number of evaluations for the two time periods was 7491. The total number of qualified and unqualified evaluations was 7491 which must match the total number of evaluations for the two time periods.

The following is a contingency table for the expected values

E_{ij}

		B	A	
		I	II	
U		162.79	208.21	371
		III	IV	
Q		3124.21	3995.79	7120
		3287	4204	<u>7491</u>

The numbers that border the table remain the same as those in the observed contingency table. The expected values for each cell were computed as follows:

Cell I: $P(U)P(B) \cdot n = \text{expected value for Cell I}$

Cell II: $P(U)P(A) \cdot n = \text{expected value for Cell II}$

Cell III: $P(Q)P(B) \cdot n = \text{expected value for Cell III}$

Cell IV: $P(Q)P(A) \cdot n = \text{expected value for Cell IV}$

where $P(U) = 371/7491$

$P(Q) = 7120/7491$

$P(B) = 3287/7491$

$P(A) = 4204/7491$

$n = 7491$

In a 2 X 2 table there is only one degree of freedom (df) for the Chi-Square value; that is, to determine $df = (r-1) \cdot (k-1)$, where r is the number of rows and k is the number of columns in the contingency table (12:105). A limitation is placed on a Chi-Square with only one degree of

freedom where each individual expected cell value must be at least five (12:46).

A Chi-Square value with one degree of freedom is depicted as χ^2_1 ; a Chi-Square critical value with a level of significance of .10 and one degree of freedom is depicted as CRIT. χ^2_1 . If the Chi-Square value of the sample, χ^2_1 is greater than the Chi-Square critical value, CRIT. χ^2_1 , then the null hypothesis (H_0) can be rejected. Thus if the computed Chi-Square value of the sample exceeds the Chi-Square critical value, a difference with respect to proficiency for the 1973 population and 1974 population can be inferred at a level of significance of .10.

The calculation of the Chi-Square value of the sample was accomplished by the following formula:

$$\chi^2_1 = \sum_{i=1}^r \sum_{j=1}^k \left(\frac{|O_{ij} - E_{ij}|}{E_{ij}} \cdot .5 \right)^2$$

where O_{ij} = the number of cases categorized in the i^{th} row of the j^{th} columns of the observed contingency table.

E_{ij} = the number of cases categorized in the i^{th} row of j^{th} column of the expected contingency table.

$|O_{ij} - E_{ij}|$ the absolute value of the difference.

$\sum_{i=1}^r \sum_{j=1}^k$ = the symbol which directs one to the sum over all (r) rows and all (k) columns.

.5 = the continuity correction for a Chi-Square with one degree of freedom.

The χ^2_1 of the sample equaled 1.36. This value did not exceed the Chi-Square critical value, CRIT. χ^2_1 of 2.71.

Thus the null hypothesis could not be rejected. Therefore, it can be inferred that proficiency of the 1973 group is equal to the proficiency for the 1974 group.

The Purposes of Regression Analysis

A purpose of the study was to determine if a relationship existed between proficiency of the KC-135 pilots and flying hours. If a mathematical model could predict this relationship, the model would be of significant value to the Air Force. In order to develop such a model, a multiple regression program (refer to Appendix B) was used. The purposes of regression analysis are:

1. The first purpose of regression analysis is to provide estimates of values of the dependent variable from values of the independent variable.
2. A second goal of regression analysis is to obtain a measure of the error involved in using the regression line as a basis for estimation. For this purpose the "standard error of the estimate" or its square, the "error variance around the regression line" are calculated [6 :464-65].

Simple Linear Regression Model - Type I

The first model to be discussed is the simple linear regression model with no transformations. The calculated data were entered as variables into the linear regression program (see Appendix B). The result was the following basic model:

$$Y = A + BX$$

where

Y = the calculated dependent variable (the difference in pilots evaluation results between the 1973 time period and the 1974 time period).

A = the regression constant = -0.51992.

B = the regression coefficient for X = .05610.

X = the independent variable (the difference in flying hours between the 1973 time period and the 1974 time period).

Thus
$$Y = -0.51992 + .05610X$$

The results of the F test of the model were: F critical equaled 3.01 and F calculated equaled 2.1482. Because F critical was greater than F calculated the model was not considered to be statistically significant. Since the model was not statistically significant further tests on the significance of the coefficient were not performed. The coefficient of determination (R^2) was .1066.

Transformation

The above model dealt with a linear model. There are many other models in which Y may depend on X. These other forms are usually nonlinear in nature. The problem that faces the researchers is deciding on which nonlinear form to apply. It is important to realize that the type of nonlinear form evaluated may depend on the experience of the researchers and the type of function being analyzed.

In developing transformations, the CURFIT program (see Appendix C) was used extensively. The CURFIT program allows the user to input the values for the dependent and independent variables. Once the values are entered, the program calculates the curves (functions) that best fit the supplied data. The type of functions that may be fitted are linear, power, hyperbolic, and exponential.

The model that held the greatest promise was a hyperbolic function. The result was the following basic model:

$$Y = A + \frac{B}{X}$$

where Y = the calculated dependent variable (the difference in pilot evaluation results between the 1973 time period and the 1974 time period).

A = the regression constant = -.2353.

B = the regression coefficient for X = 8.3333.

X = the independent variable (the difference in flying hours between the 1973 time period and the 1974 time period).

$$\text{Thus } Y = -.2353 + \frac{8.3333}{X}.$$

The coefficient of determination was .2253 which was a considerable improvement over the linear model. This improvement, however, was not considered enough to justify the hyperbolic model as a statistically significant model.

Simple Linear Regression Model - Type II

In order to determine a more direct relationship between flying hours and proficiency (as measured by the percentage unqualified) it was necessary to establish a basic standard of flying hours. This would allow the researchers to use regression analysis to determine if there was a positive relationship between the independent variable, flying hours, and the dependent variable, proficiency.

To determine the basic standard, the unit equipment (UE) factor was used. Unit equipment is defined as "... the equipment prescribed by the Table of Organization and Equipment, or national equivalents pertaining to that unit [25:202]." The unit's aircraft and support equipment are considered to be unit equipment. AFM 172-3, USAF Planning Factors, classified, contains the ratios for

aircrew to aircraft manning and aircrew compositions which are used to approve manpower spaces for aircrew positions. The aircrew manpower requirements are determined on an individual basis after analysis of the following factors:

1. Flying hours available on the aircraft to maintain proficiency of the aircrews.
2. Aircrew working hours per month.
3. Other factors, i.e., temporary duty, dispersed operating base requirements.

For crew ratio, it is the number of fully qualified or combat ready crews required that is determined (16:31XXC-1,2). The following table indicates the unit equipment and crew ratio for the KC-135 type aircraft (16:31XXC-8).

TABLE 5

KC-135 OPERATIONS MANPOWER STANDARDS

Type Aircraft/Unit	Position
KC-135	Pilots
UE-15	
CR - 1.5	46
UE-10	
CR - 1.5	30
UE-20	
CR - 1.5	60

It was decided that the UE factor rather than the number of pilot positions would be the basic standard; that is, flying hours per UE. While it is true that flying hours per pilot would be optimal, the difficulty of obtaining exact figures plus the constant turnover of personnel eliminated consideration of flying hours per pilot.

The plan for the structuring of the data for analysis and testing was as follows. The UE factors for all of the units in 8th and 15th Air Forces for the two time periods were obtained. The sample data collected were then identified by the dependent and independent variables. After the sample was selected, the variables were grouped as shown in Table 6. The grouped data in Table 6 are defined as follows:

1. Column 1. The sample Y_{Bi} data are the dependent variables. The data represented the sample pilots' evaluation results (percentage unqualified) for the period January through June, 1973.

2. Column 2. The sample Y_{Ai} data are the dependent variables. This data represented the sample pilots' evaluation results (percentage unqualified) for the period January through June, 1974.

3. Column 3. The sample X_{Bi} data represented the flying hours per unit for the period January through June, 1973.

4. Column 4. The sample X_{Ai} represented the flying hours per unit for the period January through June, 1974.

TABLE 6
GROUPING OF SAMPLE DATA FOR REGRESSION
ANALYSIS USING UE FACTOR

Dependent Variable		Independent Variable						
Y_{Bi}	Y_{Ai}	X_{Bi}	X_{Ai}	UE_i	$\frac{X_{Bi}}{UE_i}$	$\frac{X_{Ai}}{UE_i}$		
(1)	(2)	(3)	(4)	(5)	(6)	(7)		
Y_{B1}	Y_{A1}	X_{B1}	X_{A1}	UE_1	$\frac{X_{B1}}{UE_1}$	$\frac{X_{A1}}{UE_1}$		
Y_{B2}	Y_{A2}	X_{B2}	X_{A2}	UE_2	$\frac{X_{B2}}{UE_2}$	$\frac{X_{A2}}{UE_2}$		
.		
.		
.		
Y_{Bi}	Y_{Ai}	X_{Bi}	X_{Ai}	UE_i	$\frac{X_{Bi}}{UE_i}$	$\frac{X_{Ai}}{UE_i}$		

5. Column 5. The U_{Ei} is the unit equipment factor for each respective unit.

6. Column 6. The X_{BUEi} data are the independent variables. This data represented the average flying hours per UE for the periods January through June, 1973.

7. Column 7. The X_{AUEi} data are the independent variables. This data represented the average flying hours per UE for the period January through June, 1974.

The same linear regression program (see Appendix B) was used. The data were put into the program and the following was the result:

$$Y = A + BX$$

where

y = the calculated dependent variable (the percent unqualified in pilot evaluation results for the 1973 time period and the 1974 time period).

A = the regression constant = 2.3468.

B = the regression coefficient for X = .0194.

X = the independent variable (the average flying hours per UE for the 1973 time period and the 1974 time period).

Thus,

$$Y = 2.3468 + .0194X.$$

The results of the F test indicated that the model

was not statistically significant. In fact the model had a smaller coefficient of determination than the other simple linear regression model. The models that were determined from CURFIT, using the average flying hours per UE as the independent variable, were also not statistically significant with the hyperbolic function showing the highest coefficient of determination as .03759.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The research hypothesis tested was:

The proficiency of KC-135 pilots will exhibit a difference when flying hours are decreased as evidenced by differences in flying evaluation ratings.

The test results (see Chapter III) did not support this hypothesis; thus the study could not statistically conclude that the proficiency of KC-135A/Q pilots from 8th and 15th Air Forces did exhibit a difference when flying hours were decreased as evidenced by differences in flying evaluations.

Theoretically, the actual number of hours flown by pilots should affect their flying proficiency. Additionally, it is presumed that a continuous curve should exist which would show a relationship between flying hours and flying proficiency. Also, it is presumed that this curve would have a positive slope; i.e., that an increase in flying time will increase proficiency up to a certain point. The objective of this research study was to attempt to establish the theoretical relationship between flying hours and flying proficiency in order to specifically describe this presumed continuous curve.

The results of the ratio of the change in flying proficiency to the change in flying hours, i.e., the slope of this curve, indicated that the slope was not significantly positive at the points of inspection. This result does not invalidate the theoretical relationship as described above. This study only infers to the effect of the change in flying hours on proficiency to the population which was considered, specifically to those KC-135A/Q units sampled from 8th and 15th Air Forces for the population periods January through June, 1973 and January through June, 1974.

As was noted in the previous chapter, two separate tests were performed to evaluate the statistical significance of proficiency change. The Chi-Square contingency method evaluated proficiency non-parametrically. The paired comparison method evaluated proficiency parametrically. In neither case did the difference in proficiency between the two periods exhibit any statistical significance.

The study also attempted to evaluate the relationship, if any, between flying hours and proficiency by formulating a model of proficiency as a function of flying hours. The primary statistical method which was used to perform this evaluation was regression analysis. The principal objective in using regression analysis was an attempt to establish a functional model useful for prediction and/or control. This objective did not assume that there was a "cause and effect" relationship between the

predictor (flying hours) and the predicted variable (proficiency); however, it did attempt to establish a model. The linear model, $Y = A + BX$, is based on the possible outcome that the two variables tended to move in such a fashion that the value of the dependent variable ($Y =$ proficiency) could be accurately predicted from the value of the independent variable ($X =$ flying hours).

In using the linear regression method described in the previous chapter, the coefficient of determination (R^2) indicates the proportion of the total variation in the dependent variable (Y) which is explained by fitting the regression. R^2 is a dimensionless index and, from the results of this study, the value of R^2 indicated that the regression model (fitted to the values of proficiency and flying hours) did not explain the variation in proficiency with any statistical significance. In other words, no linear functional model could be determined from regression analysis which could statistically explain proficiency as a function of flying hours. As noted in Chapter III, regression analysis was performed using two different types of independent variables: 1) regression of percentage difference in proficiency (difference between the percent unqualified in the 1973 period and the percent unqualified in the 1974 period) against the percentage difference in unit flying hours (difference in flying hours for each unit between the 1973 period and the 1974 period); 2) regression of the proficiency for each unit for both the

1973 and 1974 periods (in terms of percentage unqualified for each unit for each of the two periods) against the average flying hours per UE for both the 1973 and 1974 periods.

Since no linear relationship could be statistically validated, this study proceeded to analyze the data in terms of several other functional forms by the use of a CURFIT program. The results of this evaluation (see Chapter III) could not establish, with any statistical significance, any relationship between the variables.

As a result of evaluating the research hypothesis, the following conclusions have been derived by the researchers:

1. The KC-135A/Q unit flying hour decrease (a decrease between the periods January through June, 1973 and January through June, 1974) did not have any statistically significant effect on the proficiency of the KC-135A/Q pilots as evidenced by differences in flying evaluation ratings (difference between the periods January through June, 1973 and January through June, 1974).

The researchers conject that the periods which were used might not have been long enough to totally include the effects of flying hour decreases. The researchers also conject that, based on a reduced flying hour program, more effort might have been placed by the operations' managers on the allotted flying time, thus resulting in

a more efficient use of a reduced resource. These are possible reasons for conclusion 1 which warrant consideration.

2. There was no statistically significant functional relationship between the KC-135A/Q unit flying hour decrease (the decrease between the periods January through June, 1973 and January through June, 1974) and the proficiency of the KC-135A/Q pilots as evidenced by differences in flying evaluation ratings (difference between the periods January through June, 1973 and January through June, 1974).

The researchers conject that the sample number of units evaluated might not have been sufficiently large to statistically determine a functional model which could display the relationship. Also, the researchers conject that the periods which were used might have been too small.

3. There was no statistically significant functional relationship between the average flying hours per UE (KC-135A/Q UE) for each unit and the proficiency for each unit (percentage unqualified on flying evaluations) for both periods (January through June, 1973 and January through June, 1974).

The researchers performed this analysis in order to attempt to find a more direct relationship between pilot flying hours and pilot proficiency. The difficulty

in acquiring flying hour data for individual pilots was noted in a previous section of this study. The most direct data obtainable, therefore, was average flying hours per UE.

The researchers conject that the sample number of units evaluated might not have been large enough. Also, the results noted in Chapter III indicate that an analysis of longer time periods, both before and after the reductions in flying hours, might produce a more significant relationship.

Based on these conclusions and on the researchers' evaluations, recommendations have been derived and are presented in the following section.

Recommendations

A. A study should be conducted to evaluate the effects of flying hour differences on proficiency for the KC-135 for longer time periods. The periods used in this research (January through June, 1973 and January through June, 1974) were selected in order to capture the "effects" of reductions in flying hours resulting from the fuel conservation programs initiated in the fall period of 1973. However, the researchers assume that a possible time-lag element might have affected the results. A longer period of time might reduce the variability which could exist around the theoretical distribution of the variables. Further studies might determine a more accurate time span for which this type of research should follow.

B. A study should be conducted to evaluate a feasible and accurate method of determining individual pilot flying hour changes over time. As was noted in Chapter III, due to the stochastic nature of quantifying pilots assigned to individual units for specific time periods, this level of analysis was not used in this research study. However, if a technique or methodology were developed to measure individual pilot flying hour changes over time, this could offer a more accurate tool with which to analyze the relationship, if any, between flying hours and proficiency.

C. Studies should be conducted to evaluate pilot proficiency/training programs in relation to significant changes in flying hours. The proficiency/training specifically refers to non-student-pilot flying and ground experience; i.e., the routine programs designed to assure a specific level of proficiency. The objective of such a study would be to determine if any significant change to such programs have occurred simultaneously with significant changes in flying hours. This study should parallel the research conducted for this thesis using the same population and periods which might provide some valid explanations for this thesis' findings.

D. Studies should be conducted to evaluate the effects of flying hour changes on proficiency for other types of aircraft to include such commands as Military

Airlift Command and Tactical Air Command. These studies should consider those proposals from recommendations A, B, and C. Further research could provide new findings, improved techniques, or a more thorough analysis of the topic presented in this study.

This research study has attempted to establish a methodology to evaluate the relationship between flying hours and proficiency. The study, although devoted to one aircraft type and one major air command, could be used to generate future studies on other types of aircraft, and therefore extend the analysis to the effects of flying time on proficiency throughout the Air Force. The effect of the "energy crisis" (reduction in fuel availability) was a causative factor for this research effort. However, irrespective of the future status of energy resources, specifically, aviation fuel, research to evaluate and analyze the effects of flying hours on proficiency would be justifiable in light of the continuing need to seek more efficient and effective utilization of our resources. This continuing requirement includes both the management of operations, which utilize the resources, and the management of the logistics systems which supply the resources. It is the hope of the researchers that this study would make some contribution to these continuing goals.

APPENDIX A

LISTING OF UNITS SELECTED FOR STUDY

8th AIR FORCE UNITS

Altus AFB
11 ARS
Barksdale AFB
71 ARS
913 ARS
Blytheville AFB
97 ARS
Carswell AFB
7 ARS
Griffiss AFB
41 ARS
Grissom AFB
70 ARS
305 ARS
Kincheloe AFB
908 ARS
K.I. Sawyer AFB
46 ARS
Loring AFB
42 ARS
407 ARS
McConnell AFB
91 ARS
384 ARS
Pease AFB
34 ARS
509 ARS
Plattsburgh AFB
310 ARS
380 ARS
Rickenbacker AFB
32 ARS
301 ARS
Robins AFB
912 ARS
Seymour-Johnson AFB
911 ARS
Wright-Patterson AFB
922 ARS
Wurtsmith AFB
920 ARS

15TH AIR FORCE UNITS

Beale AFB
9 ARS
903 ARS
Dyess AFB
917 ARS
Ellsworth AFB
28 ARS
Fairchild AFB
43 ARS
92 ARS
Grand Forks AFB
905 ARS
March AFB
22 ARS
Mather AFB
904 ARS
Minot AFB
906 ARS
Travis AFB
916 ARS

APPENDIX B
LISTING OF REGRESSION PROGRAM

```
10 CHARACTER ZIP*2
30 DIMENSION X(100,10),XT(10,100),Y(100,1),YT(1,100)
50 DIMENSION G(10,1),B(10,1),BT(1,10)
70 DIMENSION ST(100,20),IND(10),IDUM(10)
90 DOUBLE PRECISION HOLD(10,20),XX,XXX
110 REAL MSE,MSR
130 PRINT,"***** REGRESSION ANALYSIS *****"
150 10 PRINT,"INPUT # OF OBSERVATIONS AND # OF VARIABLES"
170 READ, JROW,JCOL
190 PRINT,"INPUT DATA(INCLUDING Y), 1 OBSERVATION AT A TIME"
210      DO 20 J=1, JROW
230 READ,(ST(J,K),K=1,JCOL)
250 20 CONTINUE
270 PRINT 410
290      DO 21 J=1, JROW
310 21 PRINT 400,(ST(J,K),K=1,JCOL)
330 PRINT," "
350 PRINT,"ARE THERE ANY ERRORS IN THE INPUT? (YES/NO)"
370 22 READ, ZIP
390 IF(ZIP.EQ."NO") GO TO 23
410 PRINT,"GIVE ME ROW, COL, AND CORRECTION"
430      READ, M, N, ERR
450 ST(M,N)=ERR
470 PRINT 400,(ST(M,J),J=1,JCOL)
490      PRINT,"MORE? (YES OR NO)"
510      GO TO 22
530 23 PRINT,"WHAT IS THE INDEX OF THE DEPENDENT VAR (Y)?"
```

```
550 READ,JY
570 DO 999 I=1,JROW
590 999 CONTINUE
610 PRINT,"GIVE THE NO. OF X'S AND A LIST OF THEIR INDICES"
630 READ,JCOL,(IND(J),J=1,JCOL)
650 DO 26 I=1,JROW
670 Y(I,1)=ST(I,JY)
690 X(I,1)=1.
710 DO 26 J=1,JCOL
730 JJ=IND(J)
750 26 X(I,J+1)=ST(I,JJ)
770 JCOL=JCOL+1
790 DO 30 K=1,JROW
810      DO 30 J=1,JCOL
830 30 XT(J,K) = X(K,J)
850      XX = 0
870      DO 70 J=1, JCOL
890      DO 60 L=1, JCOL
910      DO 50 K=1, JROW
930 50 XX = XX + XT(J,K) * X(K,L)
950      HOLD(J,L) = XX
970      XX = 0
990 60 CONTINUE
1010 70 CONTINUE
1030      K = JCOL + 1
1050      L = JCOL * 2
1070      N = K - 1
```

```

1090      DO 100 K=1, JCOL
1110      DO 90 J=K, L
1130 90  HOLD(M,J) = 0
1150      N = N + 1
1170 100 HOLD(M,N) = 1
1190      DO 160 K=1, JCOL
1210      XX = HOLD(K,K)
1230      IF (XX) 110, 260, 110
1250 110 DO 120 J=1,L
1270 120 HOLD(K,J) = HOLD(K,J) / XX
1290      DO 150 J=1, JCOL
1310      IF (J - K) 130, 150, 130
1330 130 XXX = HOLD(J,K)
1350      DO 140 M=1, L
1370 140 HOLD(J,M) = HOLD(J,M) - XXX * HOLD(K,M)
1390 150 CONTINUE
1410 160 CONTINUE
1430      KK = JCOL + 1
1450      PRINT 340
1470      DO 170 J=1, JCOL
1490      PRINT 400, (HOLD(J,K), K=KK, L)
1510 170 CONTINUE
1530      XX = 0
1550      DO 190 J=1, JCOL
1570      DO 180 K=1, JROW
1590 180 XX = XX + XT(J,K) * Y(K,1)
1610      G(J,1) = XX

```

```
1630      XX = 0
1650 190 CONTINUE
1670      L = JCOL + 1
1690      LL = JCOL * 2
1710      DO 210 J=1, JCOL
1730      M = 1
1750      DO 200 K=L, LL
1770      XX = XX + G(M,1) * HOLD(J,K)
1790 200 M = M + 1
1810      B(J,1) = XX
1830      XX = 0
1850 210 CONTINUE
1870 DO 220 J=1,JROW
1890 220YT(1,J)=Y(J,1)
1910 DO 230 J=1,JROW
1930 230XX=XX+YT(1,J)*Y(J,1)
1950 YY=XX
1970 XX=0
1990 DO 240 J=1,JCOL
2010 240BT(1,J)=B(J,1)
2030 DO 250 J=1,JCOL
2050 250XX=XX+BT(1,J)*G(J,1)
2070 ZZ=0
2090 DO 255 J=1,JROW
2110 255 ZZ=ZZ+Y(J,1)
2130 R=JROW
2150 ZZ=(ZZ*ZZ)/R
```

```
2170 SST=YY-ZZ
2190 SSR=XX-ZZ
2210 SSE=YY-XX
2230 RR=(XX-ZZ)/(YY-ZZ)
2250 PRINT 460,RR
2270 IR=JCOL-1
2290 IX=JROW-JCOL
2310 S2=SSE/IX
2330 PRINT 290, SORT(S2)
2350 PRINT, " "
2370 PRINT, "          ANALYSIS OF VARIANCE TABLE          "
2390 PRINT, "  SOURCE    VAR(SS)    DF    MEAN SQUARE    F"
2410 MSR=SSR/IR
2430 MSE=SSE/IX
2450 F=MSR/MSE
2470 PRINT 603, SSR, IR, MSR, F
2490 PRINT 604, SSE, IX, MSE
2510 PRINT 605, SST, JROW-1
2530 PRINT, " "
2550 IDUM(1)=0
2570 DO 264 I=1, JCOL
2590 264 IDUM(I+1)=IND(I)
2610 N=1
2630 PRINT, "VARIABLE    COEFFICIENT    STD ERROR    T RATIO"
2650 DO 265 K=L, LL
2670 N=N+1
2690 XX= SORT(S2)*SORT(HOLD(V, K))
```

```
2710 265 PRINT 490, IDUM(N), B(N,1), XX, B(N,1)/XX
2730 PRINT, " "
2750 GO TO 500
2770 260PRINT 270
2790 500 PRINT, "CHANGE VARIABLE LIST? W/SAME DATA(YES/NO)"
2810 READ, ZIP
2830 IF(ZIP .EQ. "NO") GO TO 505
2850 GO TO 23
2870 505 PRINT, "ANOTHER PROBLEM W/ NEW DATA? (YES/NO)"
2890 READ, ZIP
2910 IF(ZIP.EQ."NO") GO TO 510
2930 GO TO 10
2950 510 STOP
2970 270 FORMAT(1H ,23H***** NO SOLUTION ***** )
2990 280 FORMAT(1H1)
3010 290 FORMAT(1H , "STD ERROR OF THE ESTIMATE, S:", F20.7)
3030 300 FORMAT(1H ,10F12.5)
3050 310 FORMAT(F12.5)
3070 340 FORMAT(1H1,19HINVERTED MATRIX (C))
3090 350 FORMAT(10F10.5)
3110 380 FORMAT(F12.5)
3130 400 FORMAT(1H ,10F12.5)
3150 410 FORMAT(1H0, "DATA MATRIX")
3170 420 FORMAT(2I5)
3190 460 FORMAT(1H0, "COEF OF DETERMINATION (R**2):", F10.7)
3210 470 FORMAT(1H ,13HF(P-1), (N-P)=, F13.5)
3230 480 FORMAT(/)
```


3250 490 FORMAT(1H ,6X,I2,3F13.5)

3270 603 FORMAT(1H , " EXPLAINED",F15.6,I5,2F15.6)

3290 604 FORMAT(1H , " ERROR",F15.6,I5,F15.6)

3310 605 FORMAT(1H , " TOTAL",F15.6,I5)

3330 END

APPENDIX C
LISTING OF CURFIT PROGRAM

```
3REM C U R F I T
700DATA1E38,1E38
701DATA0,0
702 REM
703PRINT
704READP
705DIMX(200),Y(200),U(200),V(200),A(6),B(6),C(6),S(6),F(6)
706IFP=1E38THEN911
707FORK=1TO6
708LET F(K)=1
709NEXTK
710RESTORE
711PRINT
712PRINT"SPECIFY THE NUMBER OF VALUES (N) GIVEN AS DATA"
713PRINT"FOR BOTH INPUT VARIABLES, AND OUTPUT CODE (D)."
```

```
726 IF Y < 1E38 THEN 916
727PRINT
728PRINT
730 PRINT " L E A S T   S Q U A R E S   C U R V E   F I T"
731PRINT
732 PRINT"CURVE TYPE"," INDEX OF"," A"," B"
733PRINT" ","DETERMINATION"
734PRINT
735FOR I=1 TO 6
736FOR I1=1 TO 6
737LETS(I1)=0
738NEXT I1
739GOSUB 344
740IF (I-5)*(I-6)=0 THEN 755
741IF (I-2)*(I-3)=0 THEN 748
742FOR J=1 TO N
743LET V(J)=Y(J)
744GOSUB 822
745NEXT J
746IFI=1 THEN 765
747GO TO 776
748FOR J=1 TO N
749IFY(J) <= 0 THEN 762
750LET V(J)=LOG(Y(J))
751GOSUB 822
752NEXT J
753IFI=3 THEN 770
```

```
754GOTO765
755FORJ=1TON
756IFY(J)=0THEN762
757LETV(J)=1/Y(J)
758GOSUB3822
759NEXTJ
760IFI=6THEN776
761GOTO765
762PRINT"CAN'T FIT"
763LET(I)=0
764GOTO783
765FORJ=1TON
766LETU(J)=X(J)
767GOSUB3825
768NEXTJ
769GOTO781
770FORJ=1TON
771IFX(J)<=0THEN762
772LETU(J)=LOG(U(J))
773GOSUB3825
774NEXTJ
775GOTO781
776FORJ=1TON
777IFX(J)=0THEN762
778LETU(J)=1/X(J)
779GOSUB3825
780NEXTJ
```

```
781GOSUB386
782PRINTC(I),A(I),B(I)
783NEXTI
784IFD<>1THEN786
785GOSUB329
786PRINT
787PRINT
788PRINT
789PRINT"DETAILS FOR":
790INPUTI
791LETK=I
792LETDI=D
793PRINT
794IFF(I)=1THEN798
795GOSUB344
796PRINT" COULD NOT BE FIT."
797GOTO736
798GOSUB362
799IF(I-1)*(I-5)*(I-6)<>0THEN810
800FORJ=1TON
801LETY=A(I)+B(I)*X(J)
802IFI=1THEN806
803LETY=1/Y
804IFI=5THEN806
805LETY=X(J)*Y
806GOSUB201
807NEXTJ
```

```
808 LET D=D1
809 GOTO 786
810 FOR J=1 TO N
811 IF I=2 THEN 817
812 IF I=3 THEN 815
813 LET Y=A(4)+B(4)/X(J)
814 GOTO 818
815 LET Y=A(3)*(X(J)^B(3))
816 GOTO 818
817 LET Y=A(2)*EXP(B(2)*X(J))
818 GOSUB 3941
819 NEXT J
820 LET D=D1
821 GOTO 786
822 LET S(5)=S(5)+V(J)^2
823 LET S(3)=S(3)+V(J)
824 RETURN
825 LET S(1)=S(1)+U(J)
826 LET S(2)=S(2)+U(J)^2
827 LET S(4)=S(4)+U(J)*V(J)
828 RETURN
829 FOR I=1 TO N-1
830 LET M=I
831 FOR J=I+1 TO N
832 IF X(M) <= X(J) THEN 834
833 LET M=J
834 NEXT J
```

```
835 IF M=1 THEN 842
836 LET P=X(M)
837 LET Q=Y(M)
838 LET X(M)=X(I)
839 LET Y(M)=Y(I)
840 LET X(I)=P
841 LET Y(I)=Q
842 NEXT I
843 RETURN
844 LET K=I
845 IF K=1 THEN 860
846 IF K=2 THEN 858
847 IF K=3 THEN 856
848 IF K=4 THEN 854
849 IF K=5 THEN 852
850 PRINT "6.  $Y=X/(A+B*X)$  " ;
851 RETURN
852 PRINT "5.  $Y=1/(A+B*X)$  " ;
853 RETURN
854 PRINT "4.  $Y=A+(B/X)$  ",
855 RETURN
856 PRINT "3.  $Y=A*(X^B)$  ",
857 RETURN
858 PRINT "2.  $Y=A*EXP(B*X)$  " ;
859 RETURN
860 PRINT "1.  $Y=A+(B*X)$  ",
861 RETURN
```



```

862PRINT" ";
863GOSUB845
864PRINT" IS A";
865IFK=1THEN870
866IFK=2THEN872
867IFK=3THEN874
868PRINT" HYPERBOLIC";
869GOTO875
870PRINT" LINEAR";
871GOTO875
872PRINT" EXPONENTIAL";
873GOTO875
874PRINT" POWER";
875PRINT" FUNCTION". THE RESULTS"
876IFK=1THEN878
877PRINT" OF A LEAST-SQUARES FIT OF ITS LIN. TRANSFORM"
878IFD<>1THEN884
879PRINT" (SORTED IN ORDER OF ASCENDING VALUES OF X)"
880PRINT" ARE AS FOLLOWS:"
881PRINT
882PRINT " X-ACTUAL Y-ACTUAL YCALC PCT DIFFER"
883PRINT
884RETURN
885PRINT
886LETB=(N*S(4)-S(1)*S(3))/(N*S(2)-(S(1)^2))
887LETA=(S(3)-B*S(1))/N
888LETS1=S(5)-(S(3)^2)/N

```

```

889 LET S2 = (B^2) * (S(2) - (S(1)^2) / N)
890 LET C(I) = S2 / S1
891 IF (I-1) * (I-4) * (I-5) = 0 THEN 898
892 IF (I-2) * (I-3) = 0 THEN 896
893 LET A(6) = B
894 LET B(6) = A
895 RETURN
896 LET A(I) = EXP(A)
897 GOTO 899
898 LET A(I) = A
899 LET B(I) = B
900 RETURN
901 PRINT X(J), Y(J), Y.
902 LET D = Y(J) - Y
903 LET D = .1 * SIGN(D) * INT(1000 * ABS(D/Y))
904 IF D < 0 THEN 909
905 IF D > 0 THEN 908
906 PRINT "      0"
907 RETURN
908 PRINT "      "
909 PRINT D
910 RETURN
911 PRINT
912 PRINT "LIST FILE 'STADES' FROM LIBRARY FOR INSTRUCTIONS"
913 PRINT "----"
914 PRINT
915 STOP

```

916 PRINT

917 PRINT"CHECK INPUT"

9999 END

SELECTED BIBLIOGRAPHY

A. REFERENCES CITED

1. AF Times [Washington, D.C.], December 4, 1974, p. 8.
2. AF Times [Washington, D.C.], December 4, 1974, p. 28.
3. Benvenuti, Colonel John R. D., USAF. Chief, Energy Management Division, Headquarters USAF. Washington, D.C. Telephone Interview. 11 October 1974.
4. Degrotte, Major John, USAF. Office of the Director of Training, Headquarters Strategic Air Command. Offutt Air Force Base, Nebraska. Telephone Interview. 10 October 1974.
5. Gunnell, Lieutenant Colonel J. E., USAF. Chief of Flight Safety, Office of the Inspector General, Headquarters Air Force Logistics Command. Wright-Patterson Air Force Base, Ohio. Personal Interview. 1 October 1974.
6. Hamburg, Morris. Statistical Analysis for Decision Making. New York: Harcourt, Brace and World, Incorporated, 1970.
7. Helmstadter, G. C. Research Concepts in Human Behavior. New York: Meredith Publishing Inc., 1970.
8. John, Peter W. M. Statistical Design and Analysis of Experiments. New York: The MacMillan Company, 1971.
9. Jones, Major D., USAF. Office of the Director of Training, Headquarters 15th Air Force. March Air Force Base, California. Telephone Interview. 9 October 1974.
10. Morley, Staff Sergeant Walter J., USAF. Analysis Branch, First Combat Evaluation Group. Barksdale Air Force Base, Louisiana. Telephone Interview. 8 October 1974.

11. Mundie, Major Bruce K., USAF. Office of the Director of Safety, Deputy Chief of Staff for Operations, Hq Strategic Air Command. Offutt AFB, Nebraska. Telephone Interview. 4 December 1974.
12. Pearce, Major Frank, USAF. Office of the Director of Training, Hq 2nd Air Force. Barksdale AFB, Louisiana. Telephone Interview. 8 October 1974.
13. Siegel, Sidney. Nonparametric Statistics for the Behavioral Sciences. New York: McGraw-Hill Book Company, 1956.
14. Sonenshein, Rear Admiral. "Effects of Energy Problems on DOD." Navy Supply Corps Newsletter, Vol. 37, No. 2 (March, 1974), pp. 1-10.
15. Thome, Benny O. "SEA Effects on SAC's KC-135 Pilot Training Programs." Unpublished Air Command and Staff College Research Study, Air University, Maxwell AFB, Alabama, May, 1973.
16. U.S. Department of the Air Force. Air Force Manpower Standards Mission Equipment Maintenance and Operations. AFM 26-3, Vol. III, Washington, D.C.: Government Printing Office, 27 February 1974.
17. _____. Directory and Mission Directives of Strategic Air Command Organizations. SACM 23-3. Offutt AFB, Nebraska: Government Printing Office, 1 August 1972.
18. _____. Flight Management Policies. AFM 6-1, Washington, D.C.: Government Printing Office, 15 January 1973.
19. _____. Initial Qualification, Upgrade, Difference, Requalification and Contingency Indoctrination Training for SAC Aircrew Members. SACM 51-10. Offutt AFB, Nebraska: Government Printing Office, 22 January 1973.
20. _____. Investigating and Reporting US Air Force Accidents and Incidents. AFR 127-4. Washington, D.C.: Government Printing Office, 1 January 1973.
21. _____. Operational Readiness Inspection. SACM 50-5. Offutt AFB, Nebraska: Government Printing Office, 12 June 1972.
22. _____. Standardization/Evaluation Program. SACM 60-4, Vol. I. Offutt AFB, Nebraska: Government Printing Office, 15 March 1974.

23. . Training Concepts, Policies, and Instruc-
tions-SAC Units and Aircrews. SACM 51-8, Vol. I.
Offutt Air Force Base, Nebraska: Government
Printing Office, 14 June 1974.
24. . United States Air Force Basic Doctrine.
AFM 1-1. Washington, D.C.: Government Printing
Office, 28 September 1971.
25. . United States Air Force Glossary of
Standardized Terms. AFM 11-1, Vol. I, Washing-
ton, D.C.: Government Printing Office,
1 January 1973.
26. Wheeler, Major Maurice J., USAF. Office of Opera-
tions and Training, Headquarters Strategic Air
Command. Offutt Air Force Base, Nebraska.
Telephone Interview. 4 December 1974.
27. Wonnacott, Thomas H., and Ronald J. Wonnacott. In-
troductory Statistics for Business and Economics.
New York: John Wiley and Sons, 1972.
28. Wyatt, Woodrow W. and Charles M. Bridges, Jr.
Statistics for the Behavioral Sciences.
Boston: D. C. Heath and Company, 1967.

B. RELATED SOURCES

- Altick, Major Stephen F., USAF and Richard L. Speros, USAF.
"An Examination of the Whole Man Concept Applied to
Tactical Mission Personnel." 0045-74, Air Command
and Staff College, Maxwell Air Force Base, Alabama,
May, 1974.
- Campbell, William G., and Stephen V. Ballou. Form and
Style: Theses, Reports, Term Papers. 4th ed.
Boston: Houghton Mifflin Company, 1974.
- Dambrauskas, Lieutenant Colonel Vincent, USA. "Self-
Sufficiency B-2 in Energy-A National Policy?"
Carlisle Barracks, Pennsylvania: U.S. Army War
College, 1973.
- Druva, Karlis. "Air Crew Standardization/Evaluation in
Strategic Air Command." Unpublished Air Command
and Staff College Research Study, Air University,
Maxwell Air Force Base, Alabama, May, 1974.

Hayes, James H. "Petroleum - A Prediction Made in 1950." P. 5135. RAND Corporation, Santa Monica, California, December, 1973.

Henderson, Captain Stephen. Instructor of Logistics Management, School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson Air Force Base, Ohio. Personal Interview. 17 January 1975.

Mutch, James J. "The Potential for Energy Conservation in Commercial Air Transport." R-1360, RAND Corporation Santa Monica, California, October, 1973.

Planning Research Corporation. "Proficiency Flying Program Study." PRC R-952, Prepared for Office of Secretary of Defense Systems Analysis, Washington, D.C., March, 1967.

Schrad, David A., and Michael Hanley. "A Comparative Analysis of Proficiency Aviator Skills, Knowledge and Satisfaction." NPS-55S071031A, Naval Postgraduate School, Monterey, California, March, 1971.

Tarr, Alfred E. "An Analysis of SAC Aircrew Training Programs," Unpublished Air Command and Staff College Research Study, Air University, Maxwell Air Force Base, Alabama, May, 1973.

U.S. Department of the Air Force. "Style and Guidelines Manual for Thesis and Technical Reports." 4th rev. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson Air Force Base, Ohio, May, 1974.

U.S. Government. Office of the Assistant Secretary of Defense (Installations and Logistics). Management of Defense Energy Resources, Chapters 1-8, Washington, D.C.: Government Printing Office, November, 1973.

_____. Management of Defense Energy Resources, Chapter 9, Washington, D.C.: Government Printing Office, November 1973.

_____. Management of Defense Energy Resources, Executive Summary. Washington, D.C.: Government Printing Office, November, 1973.

Willis, Ronald E., and Norman L. Chervany. Statistical Analysis and Modeling for Management Decision-Making. Belmont, California: Wadsworth Publishing Company, 1974.

Wright, Robert H. "Retention of Flying Skills and Refresher Training Requirements: Effects of Non-Flying and Proficiency Flying." Technical Report, 73-32, The Human Resources Research Organization, Alexandria, Virginia, December, 1973.

END